STUDIES ON HETEROSIS AND COMBINING ABILITY ANALYSIS OF SOME CHARACTERS IN RAPESEED (*BRASSICA NAPUS* L.).

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ABSTRACT

The present investigation was carried out to study heterosis and combining ability using five rapeseed lines and their possible crosses excluding reciprocals. The results indicated that significant positive heterosis estimates were found for all crosses in the case of yield/plant and in most crosses for the traits; plant height, 1000-seed weight, number of primary branches and oil percentage, while significant negative heterosis estimates were found in all crosses for days to flowering, with the exception of cross 3. General and specific combining ability variances were highly significant for all the studied traits with the exception of general combining ability of 1000-seed weight. However, the variance ratio suggested preponderance of additive variance in the inheritance of all traits with the exception of 1000-seed weight. Significant general combining ability effects were obtained and results revealed that no one parent was a general good combiner for all traits examined. Specific combining ability effects varied from one cross to another with either negative or positive values. Results showed that genetic variation of all traits resulted mainly from the variance of general combining ability, that is, additive effects dominated the heredity. So, according to the selection of general combining ability for parents, these traits could be improved.

Keywords: rapeseed, heterosis, combining ability

INTRODUCTION

Rapessed (*B. napus* L.) is grown in a large part of the world for its oil and meal, oil contains 62% monosaturated fat and 32% polyunsaturated fat. Indeed, production and usage of Brassica oil seed have grown faster in the period 1975-1985 than any other oil crop (Downy *et al.*, 1989). In 1999/2000, 13.37 million metric tons* represent 16% of the world's edible oil supply comes form Brassica oil seed (rapeseed and mustard). Though this crop is adaptable to different conditions in the world, its scope as a major oil seed crop will depend upon breeders efforts to evolve

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* Counselor and Attach Reports Official Statistics, USDA estimates, July 1999.

agronomically suitable cultivars. In Egypt, due to the rapid increase in population there is a growing demand for vegetable oil. At present, Egypt imports about 4/5 of its annual requirements of edible vegetable oils. These imports draw a heavy bill on the foreign currency reserve of the country. A possible remedy to the present gap between the domestic production of and demand for edible oil could be the use of new oil crops. Only scanty information is available about the type of gene effects involved in the inheritance of seed yield and its components.

Information pertaining to the inheritance of economic characters in rapeseed under Egyptian condition is too limited. The present investigation aimed to find out the genetic behaviour of some economic characters in crosses between some inbreds of rapeseed which might offer valuable opportunity to the breeders to select the best breeding material in both field and laboratory on the basis of seed characters.

MATERIALS AND METHODS

Five parental inbred lines all belonging to *Brassica napus* L. ($2n = 38$) and designated as Int. 315, Int. 316, Int. 322, Int. 323 and Int. 324 were crossed to obtain ten possible F_1's* excluding reciprocals at Sakha Agric. Res. Station Farm in 1998/1999 season. The parents were obtained from Agric. Res. Center, Oil Crops Section. In 1999/2000 season all the F_1 hybrids along with their parents were evaluated in a randomized complete block design experiment with three replications. Each plot contained four rows 4 m long and 60 cm wide and each row had 40 hills spaced 10 cm apart.

Data were recorded in respect of (1) date to flowering (2) plant height (cm), (3) number of primary branches, (4) seed yield/plant (g) (5) 1000-seed weight and (6) oil percentage determined from a seed sample of 4 grams using Carver laboratory press in the laboratory of Oil Crops. Res. Section. Field Crops Res. Inst., Agric. Res. Center. This method was previously described by Comstock and Culbertson (1958).

The analysis of variance was carried out on plant mean basis. Heterosis was calculated as percent of mid-parent as follows:

$$\text{Heterosis of mid-parent (M.P.)} = \frac{\overline{F}_1 - \overline{M}.P.}{\overline{M}.P.} \times 100$$

A test of significant was conducted using the formula suggested by Steel and Torrie (1960).

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* 1-Int. 315 x Int. 316 2- Int. 315 x Int. 322 3- Int. 315 x Int. 323. 4- Int. 315 x Int. 324. 5- Int. 316 x Int. 322 6- Int. 316 x Int. 323 7- Int. 316 x Int. 324 8- Int. 322 x Int. 323 9- Int. 322 x Int. 324 10- Int. 323 x Int. 324.

$$\text{L.S.D.} = t\sqrt{\frac{M\ \ se}{r} + \frac{n1 + n2}{n1\,n2}}$$

Where:

Mse = the error mean square of F_1.
r = number of replications.
n1 = number of hybrids
n2 = number of parents.

Furthermore, the obtained data were analyzed using Griffing's method 2 model-1 procedure (1956) to estimate the general and specific combining ability effects.

RESULTS AND DISCUSSION

The analysis of variance presented in Table (1) revealed that highly significant differences existed between entries; among the parents as well as among the crosses for all the studied traits with the exception of 1000-seed weight.

Table (1). Analysis of variance among parents and F_1's for the studied characters.

S.O.V.	d.f.	Mean squares					
		Number of days to flowering	Plant height	Number of primary branches	Seed yield per plant	1000-seed weight	Oil %
Reps	2	9.077	5.618	0.627	5.365	0.064	0.303
Entries	14	127.813**	596.110**	1.851**	48.220**	0.166**	19.092**
Parents	4	134.408**	748.990**	3.245**	53.186**	0.085	33.799**
F_1 (crosses)	9	121.635**	567.967**	1.417**	27.347**	0.188**	11.351**
P.vs.Cr. (Heter.)	1	127.027**	237.884**	0.178	216.225**	0.299*	9.927**
Pooled error	28	1.329	21.907	0.139	3.90	0.0485	0.1099

* Significant at 5% level
** Significant at 1% level

Heterosis:

Early reports of heterosis in rapeseed cultivar hybrids, coupled with the availability of cytoplasmic male sterility, have stimulated much research into the development of hybrid rapeseed cultivars (Shuster and Micheal, 1976 and Shiga, 1976). Recent work demonstrated high level of heterosis (30-60% of mid-parent) for seed yield in inter-cultivar rapeseed hybrids (Sernk and Stefansson, 1983 and Grant and Beversdort, 1985).

With regard to heterosis percentage estimated as deviation of the F_1 from the mid-parent (M.P.), for the six studied traits, the results given in Table (2) showed that significant heterosis estimates were obtained for all crosses in the case of number of days to flowering, number of primary branches, seed yield/plant, 1000-seed weight with the exception of cross 6 and oil content. For plant height trait significant estimates were obtained for crosses 1, 2, 3 and 9. For days to flowering consistent negative heterosis estimates may lead to a proportional earliness in the crosses including parental inbred lines. However, seed yield/plant showed extensive positive heterosis, this result is of economic importance since this trait is one of the yield components in rapeseed. With regard to plant height 4 crosses showed negative heterosis estimates and these estimates lead to a proportional dwarfness in the crosses including parental inbred lines. For number of primary branches and 1000-seed weigh traits the estimates varied from positive to negative while for oil content negative estimates were recorded for only two crosses (8 and 9) and the other crosses gave positive estimates. In the present study, pure lines were used as parents, however, variable heterosis estimates were recorded for the different crosses. This indicated that the genetic constitution of the parental lines was different. Furthermore, the degree of heterosis depended primarily on the extent of separation of the two parents involved in the cross. Rapeseed cultivars used as parents of hybrids had previously been assumed to be completely homozygous (Grant, 1984). While, Brandle and McVetty (1989) explained that rapeseed cultivars are, in fact, genetically heterogeneous. Therefore, it could be possible to select within the two parents of heterotic cultivar cross, that will give maximum heterosis upon crossing, rather than the average heterosis that had been observed in the original cultivar cross. These results agree with those obtained by Sernk and Stefansson (1983) and Brandle and McVetty (1989).

Table (2). Heterosis in percentage relative to the mid-parent for the studied characters.

Crosses	Mean squares					
	Number of days to flowering	Plant height	Number of primary branches	Seed yield per plant	1000-seed weight	Oil %
1. Int. 315 x Int.316	-6.260**	-7.572*	-15.195**	11.501**	1.156**	1.223**
2. Int. 315 x Int. 322	-2.951**	12.320**	-24.919**	23.747**	2.711**	4.243**
3. Int. 315 x Int. 323	7.761**	10.504**	-12.925**	11.709**	-3.458**	3.533**
4. Int. 315 x Int. 324	-7.445**	0.145	-9.927**	21.300**	-3.216**	7.043**
5. Int. 316 x Int. 322	-2.116*	-0.631	13.844**	10.889**	-1.238**	4.348**
6. Int. 316 x Int. 323	-5.568**	5.683	8.112**	21.335**	0.00	5.782**
7. Int. 316 x Int. 324	-8.062**	-0.362	3.026**	38.143**	3.604**	4.277**
8. Int. 322 x Int. 323	-2.748**	-3.033	-0.961**	31.663**	17.284**	-5.078**
9. Int. 322 x Int. 324	-11.279**	13.709**	18.595**	36.656**	14.734**	-2.998**
10. Int. 323 x Int. 324	-4.032**	2.759	9.612**	30.006**	20.359**	2.928**
L.S.D. 0.05	1.669	6.778	0.541	2.859	0.317	0.479
0.01	2.252	9.146	0.729	3.857	0.428	0.647

Combining ability:

a. Variances:

Examination of Table (3) revealed that both g.c.a. and s.c.a. variances were highly significant, with the exception of 1000-seed weight trait in the case of g.c.a., indicating that both additive and non-additive genetic components were important in controlling these traits with the first being more important due to its higher values. The fact that 1000-seed weight trait has insignificant g.c.a., while it has highly s.c.a. indicates that this trait is mainly controlled by the non-additive gene effect. These results are in agreement with those obtained by Gupta *et al.* (1983), Yadav and Yadava (1983), Prasad and Singh (1986), Chaudhary *et al.* (1987), Zao and Yanfei (1989), Yadava and Yadav (1991), Dhari and Yadava (1992), Galal *et al.* (1992) and Yadav and Singh (1993) where they pointed out that both additive and non-additive gene action contributed to the control of these traits, but additive gene action was more important in the inheritance of these traits.

Table (3). Analysis of variance for entries, combining ability and error variance for the studied characters.

S.O.V.	d.f.	Mean squares					
		Number of days to flowering	Plant height	No of primary branches	Seed yield per plant	1000-seed weight	Oil %
Entries	14	127.813**	596.110**	1.851**	48.220**	0.166**	19.092**
g.c.a.	4	99.918**	457.50**	0.651**	31.845**	0.0323	16.817**
s.c.a	10	19.667**	95.193**	0.603**	9.70**	0.0644**	2.184**
E'*	28	0.443	7.30	0.0464	1.301	0.016	0.0367
g.c.a: s.c.a		5.08: 1	4.81: 1	1.08: 1	3.28: 1	0.502: 1	7.7: 1

* E' : error term is used for testing g.c.a and s.c.a variances according to Griffing's (1956).

b. G.C.A./S.C.A. ratio:

The estimates due to general and specific combining ability were utilized to calculate the ratio of g.c.a.: s.c.a. as a measure to reveal the nature of the genetic variance involved, i.e. additive versus non-additive genetic effects. It could be seen from the results given in Table (3) that the ratio obtained were consistently more than unity for all the studied traits, with the exception of 1000-seed weight trait. These results suggest that the additive portion of the genetic variance predominates and controls all the traits. However, these results revealed that both g.c.a. and s.c.a. variances were significant, with the exception of g.c.a. in the case of 1000-seed weight trait, indicating that both additive and non-additive variances were present but the additive plays a major role in the inheritance of these traits. Therefore, the use of a breeding method capitalizing both additive and non-additive variances would be imperative. These results confirmed those reported by Zao and Yanfei (1989) and Galal *et al.* (1992). Similarly, those workers also found that variance for general and specific combining ability were highly significant and both additive and non-additive gene effects were present and control the inheritance of the studied traits. So, according to the selection of general combining ability for parents, these traits could be improved with the exception of 1000-seed weight trait while the variance ratio of specific combining ability was greater than that of general combining ability, this result showed that the function of the non-additive effect of this trait dominated the formation of hybrid characters which in turn made the selection of combination more important in breeding.

c. G.C.A. and S.C.A. effects:

1. G.C.A. effects:

General combining ability effects (gi) of the parents for the different traits are shown in Table (4). The results varied from one parent to another with either negative or positive values.

For days to flowering it could be seen from Table (4) that Int. 322 possessed the highest significant positive effect indicating that it is a late line and has the highest number of days to flowering. On the other hand, Int. 324 possessed significant negative estimate indicating that it is early flowering.

As regard to plant height trait, g.c.a. effects showed that Int. 322 had the highest significant positive g.c.a. effect, whereas Int. 324 showed significant negative estimate.

With respect to number of primary branches, Int. 316 and Int. 322 had the highest positive g.c.a effects. Moreover, either negative or positive estimates ere recorded for the other parents with either significant or insignificant estimates.

Table (4). General combining ability effects for the studied characters.

Cultivars	Mean squares					
	Number of days to flowering	Plant height	Number of primary branches	Seed yield per plant	1000-seed weight	Oil %
Int. 315	1.411**	2.270	0.101	5.039**	-0.0049	-1.952**
Int. 316	0.655*	0.147	0.248*	6.010**	-0.063	-0.943**
Int. 322	4.205**	9.812**	0.214*	9.083**	-0.066	0.192*
Int. 323	-0.192	0.408	-0.131	4.686**	0.089	2.132**
Int. 324	-6.079**	-12.640**	-0.468**	3.419**	0.045	0.571**
S.E. *	0.225	0.913	0.073	0.386	0.0428	0.065
C.D. 0.05**	0.610	2.470	0.198	1.046	0.116	0.176
C.D. 0.01**	0.916	3.720	0.297	1.570	0.174	0.265

* S.E. : standard error

** C.D. : critical differences for making comparison between different effects.

For seed yield per plant trait, all g.c.a. effects were significant and positive, 1000-seed weight, however, showed insignificant estimates for all parents with either positive or negative estimates.

Considering oil percentage the results showed that significant positive estimates were recorded for Int. 322, Int. 323 and Int. 324 indicating their high oil percentage, while, significant negative estimates were detected for the two parents; Int. 315 and Int. 316.

Finally, it could be concluded that the general combining ability effects revealed that Int. 322 was a general good combiner for yield, plant height and number of primary branches traits. On the other hand, Int. 324 was a general good combiner for earliness. The parent Int. 323 was shown to be the top good general combiner for oil percentage. It could be concluded that the results gained on general combining ability effects revealed that none of the used parents was a general good cobminer for all the traits examined. This indicated that the probable use of multiple crosses to attain substantial improvement for all traits.

2. S.C.A. effects:

Specific combining ability effects (Sij) for the studied traits are given in Table (5).

Table (5). - Specific combining ability effects for the studied characters.

Crosses	Mean squares					
	Number of days to flowering	Plant height	Number of primary branches	Seed yield per plant	1000-seed weight	Oil %
1. Int. 315 x Int.316	-3.71**	-11.860**	-0.638**	0.354	0.115	-0.875**
2. Int. 315 x Int. 322	-0.990	13.470**	-1.328**	2.511*	0.035	1.523**
3. Int. 315 x Int. 323	7.037**	11.210**	-0.354	-0.120	-0.185	0.799**
4. Int. 315 x Int. 324	-3.346**	-4.080	-0.244	0.680	-0.185	1.680**
5. Int. 316 x Int. 322	1.527*	-2.730	0.819**	-0.690	-0.131	1.330**
6. Int. 316 x Int. 323	-3.523**	8.170**	0.393	1.537	-0.095	1.570**
7. Int. 316 x Int. 324	-2.240**	-0.780	-0.134	3.504**	0.015	0.642**
8. Int. 322 x Int. 323	-1.327*	-10.260**	-0.167	3.369**	0.325*	-2.154**
9. Int. 322 x Int. 324	-5.840**	13.710**	1.079**	3.130*	0.235	-1.414**
10. Int. 323 x Int. 324	-0.803	-0.540	0.316	1.230	0.435**	0.696**
S.E. *	0.459	1.865	0.149	0.787	0.087	0.132
C.D. 0.05 **	1.244	5.050	0.404	2.133	0.237	0.358
C.D. 0.01**	1.868	7.590	0.606	3.203	0.355	0.537

* S.E. : standard error

** C.D. : critical differences for making comparison between different effects.

For days to flowering trait, significant negative effects were obtained for crosses 1, 4, 6, 7, 8 and 9. However, significant positive s.c.a. effects for crosses 3 and 5 were also noted.

Significant positive s.c.a effects were estimated for plant height trait, with the exception of the two crosses 1 and 8 which showed significant negative estimates.

With respect to number of primary branches, significant positive s.c.a. effects were determined for the two crosses; 5 and 9. Significant negative estimates, however, were obtained for the two crosses: 1 and 2.

For yield/plant, significant positive s.c.a. effects were obtained for the four crosses; 2, 7, 8 and 9. As regard to 1000-seed weigh trait, two crosses showed significant positive s.c.a. effects.

Concerning oil percentage, results given in Table (5) showed that the ten studied crosses gave significant estimates of which three crosses; 1, 8 and 9 had negative effects. However, the seven remaining crosses gave positive effects.

The preponderance of the significant negative specific combining ability estimates recorded in Table (5) for the different traits suggest that insufficient amount of variance due to non-additive gene action is existent, this indicates that the major portion of the genetic variance resulted from genes with additive effects. However, the observed heterosis indicates the presence of some types of non-additive gene effects other than the dominance variance. This could be attributed to the interacting gene effects. The estimates of sizable amounts of additive genetic variance in the base population certainly suggest that significant advancements can be made through the use of selection procedures which increase the frequency of favourable genes showing primarily additive effects. On the other hand, the presence of non-additive variance indicates the ultimate genetic advance, therefore, would depend upon breeding procedures which utilize both types of genetic variance. These results agree with those reported by Prasad and Singh (1986), Chaudhary *et al.* (1987), Zao and Yenfei (1989), Yadava and Yadav (1991), Dhari and Yadava (1992) and Yadav and Singh (1993).

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الملخص العربى

دراسات على قوة الهجين والقدرة على الإئتلاف لبعض الصفات فى الريب

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أجريت هذه الدراسة فى محطة البحوث الزراعية بسخا – كفرالشيخ – مركز البحوث الزراعية خلال موسمى ١٩٩٨/١٩٩٩ ، ١٩٩٩/٢٠٠٠م بهدف دراسة قوة الهجين والقدرة الإئتلافيه الخاصة والعامة فى مجموعة من الهجين التبادلية لعدد من سلالات الريب.

ويمكن تلخيص أهم النتائج التى تم التوصل إليها فيما يلى:

١- أظهرت النتائج أن هناك قوة هجين ظاهرة لمعظم الصفات التى تم دراستها وكانت قوة الهجين موجبة ومعنوية لصفة محصول النبات ومعظم الهجن لصفة نسبة الزيت ، بينما كانت سالبة ومعنوية لصفة عدد الأيام للتزهير وقد أظهرت باقى الصفات قيما معنوية سالبة وموجبة.

٢- وجدت القدرة العامة والخاصة على الإئتلاف بمعنوية عالية لجميع الصفات التى تم دراستها ما عدا القدرة العامة على الإئتلاف لصفة وزن ١٠٠٠ بذرة ، ولعبت القدرة العامة على الإئتلاف دورا كبيرا فى توارث معظم الصفات.

٣- كانت الاختلافات الراجعة لتأثير كلا من القدرة العامة والخاصة على الإئتلاف فعاله ومعنوية لمعظم الآباء والهجن فى معظم الصفات.

٤- أظهرت النتائج أن كل الصفات يتحكم فى وراثتها كل من التأثير المضيف والسيادى مع كون الأول ذو تأثير كبير على كل الصفات